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ISSUE DATE: ***September 06, 1994***

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United States Patent [19]

Woodmas

[11] Patent Number: 5,345,592

[45] Date of Patent: Sep. 6, 1994

[54] **SIGNAL TRANSFER AND POWER DELIVERY SYSTEM FOR A TELEVISION CAMERA STATION**

[75] Inventor: **Charles D. Woodmas**, Lyndon, Kans.

[73] Assignee: **Concept W Systems, Inc.**, Emporia, Kans.

[21] Appl. No.: **866,664**

[22] Filed: **Apr. 8, 1992**

[51] **Int. Cl.**[5] **H04B 3/54**

[52] **U.S. Cl.** .... **455/3.3**; 455/5.1; 340/310 A

[58] **Field of Search** .... 358/86; 455/3.1, 3.3, 455/5.1, 6.3; 340/310 R, 310 A, 310 CP

[56] **References Cited**

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Primary Examiner—Reinhard J. Eisenzopf

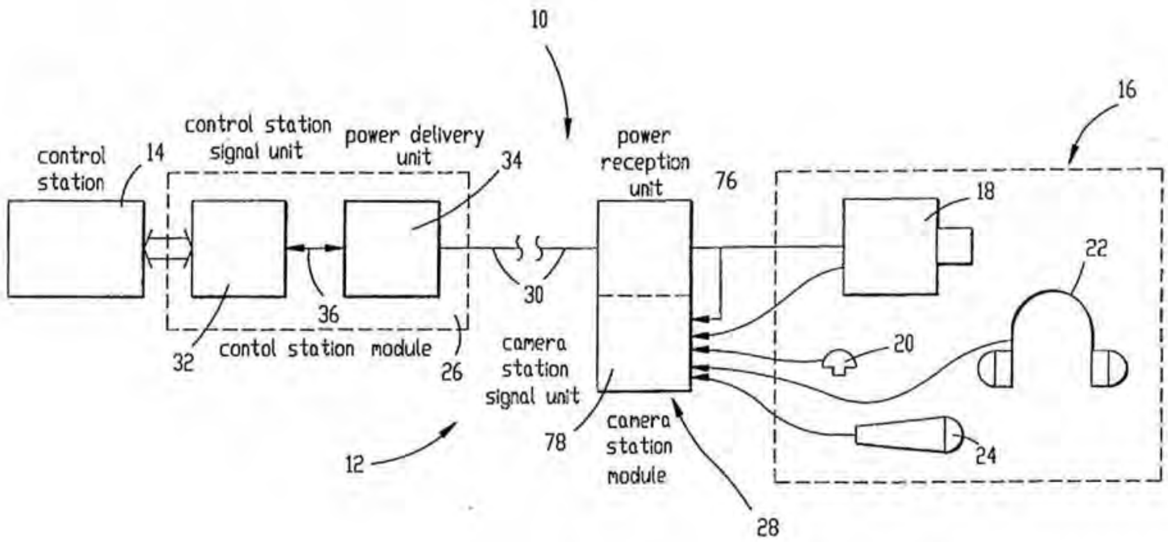
Assistant Examiner—Chi Pham

Attorney, Agent, or Firm—Hovey, Williams, Timmons & Collins

[57] **ABSTRACT**

A television production system provides both signaling and power over a single coaxial cable between a television control station and a remote camera station. The control station includes a power delivery unit for coupling with the coaxial cable for delivering D.C. voltage and current along with signaling over the coaxial cable. The camera station includes a power receiving unit which receives power from the coaxial cable and delivers it to the television camera and other camera station equipment. The receiving unit also monitors the received voltage and provides a power status signal representative thereof over the cable to the power delivery unit. The delivery unit controls the delivered voltage in accordance with the status signal in order to maintain the received voltage at the camera station at a desired level in order to compensate for cable voltage drop.

31 Claims, 5 Drawing Sheets



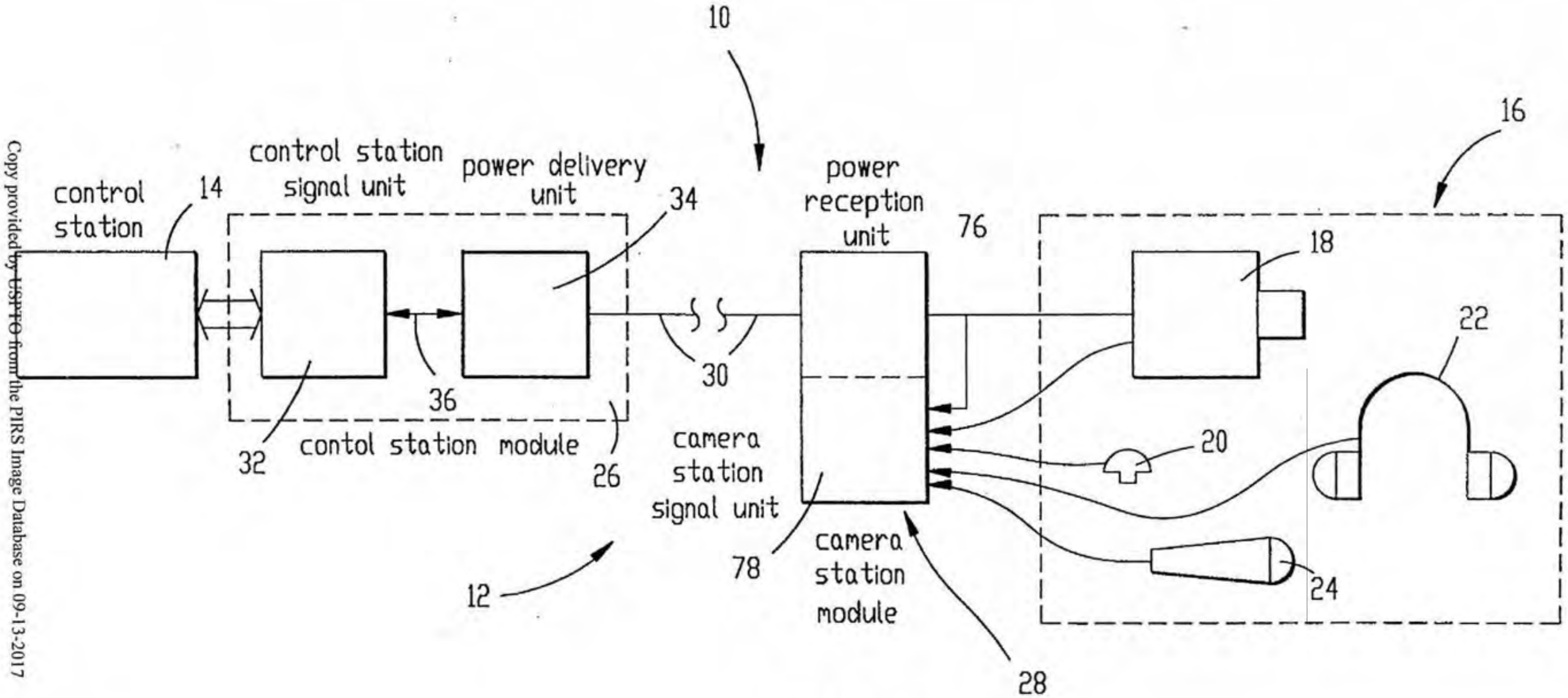
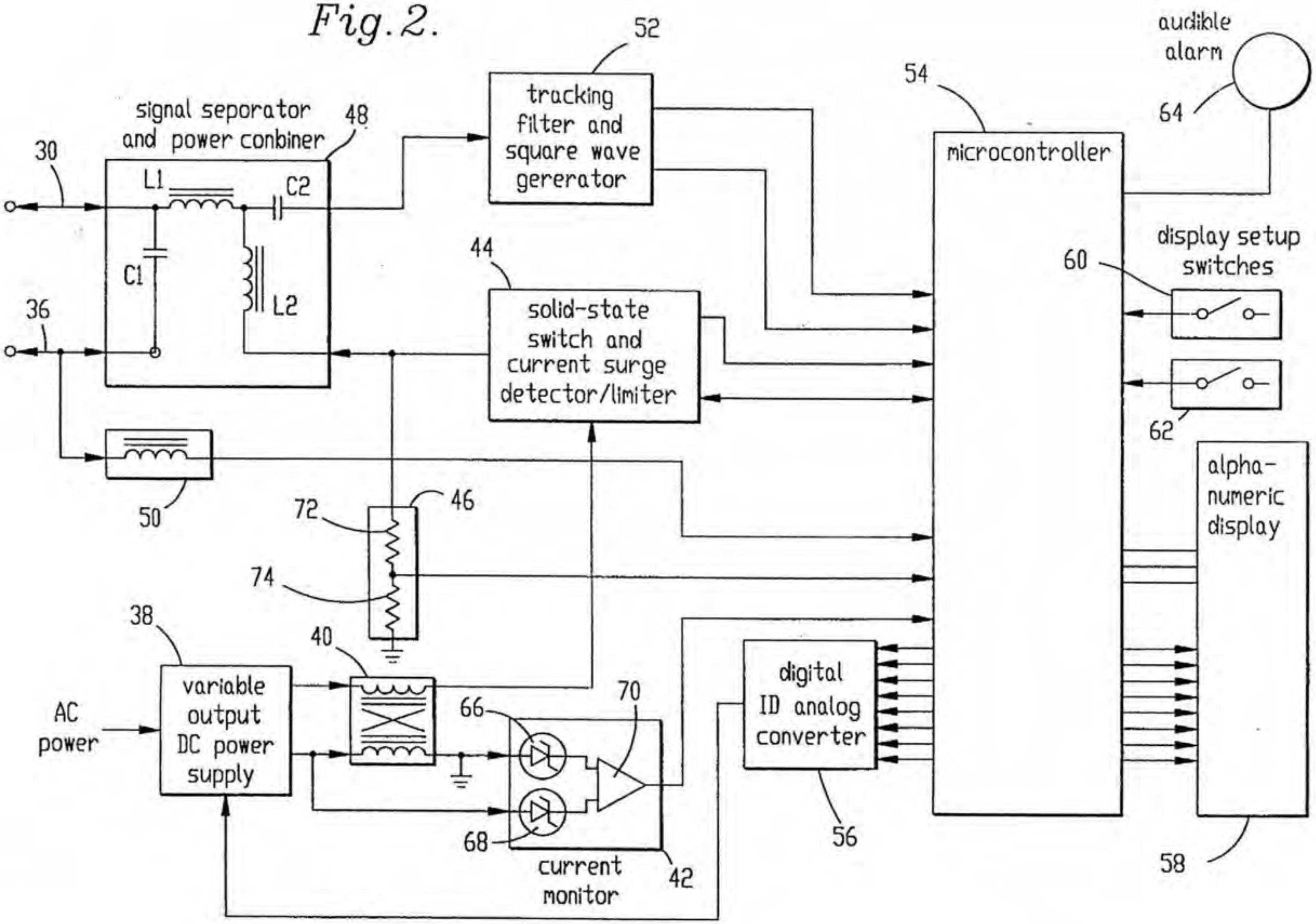
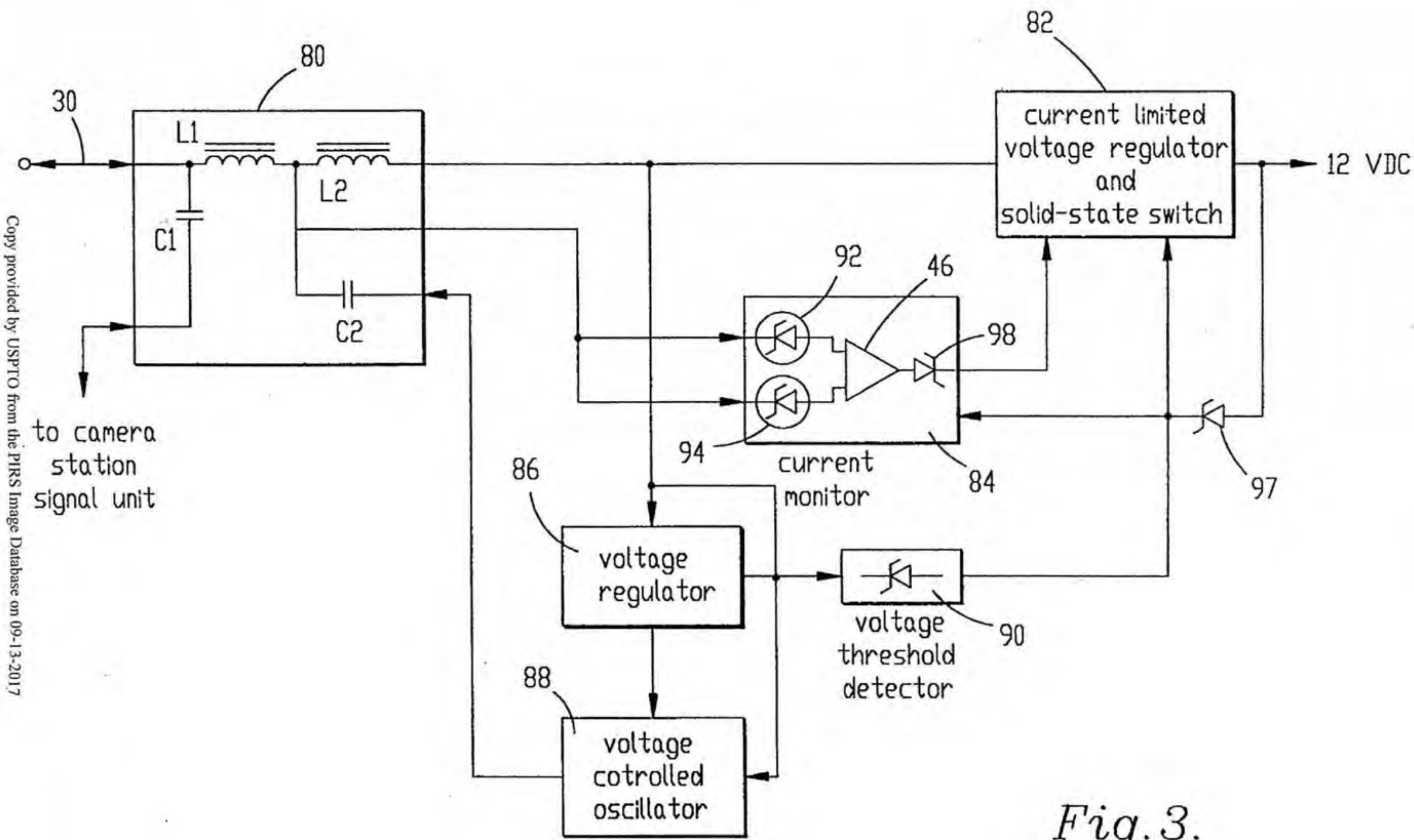

10
control station
14
control station signal unit
power delivery unit
34
power reception unit
76
16
18
22
36
30
32
contol station module
26
camera station signal unit
20
12
78
camera station module
24
28

Fig. 1.

Fig.2.

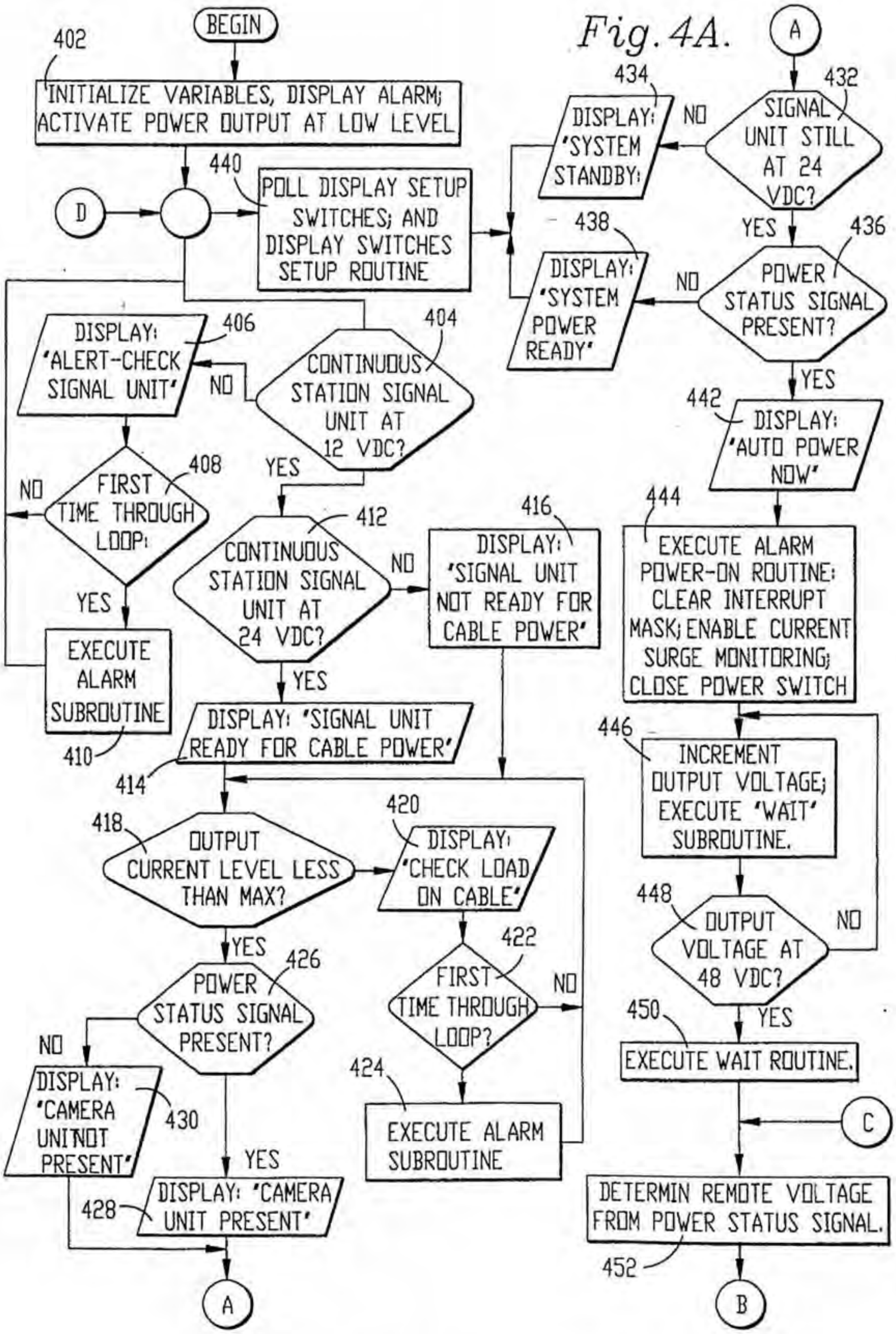

52
tracking filter and square wave gererator
54
microcontroller
audible alarm
64
signal seporator and power conbiner
48
30
L1
C2
C1
L2
36
44
solid-state switch and current surge detector/limiter
display setup switches
60
62
50
72
46
74
alpha-numeric display
38
40
variable output DC power supply
AC power
66
70
digital ID analog converter
68
current monitor
42
56
58



82
80
30
current limited
voltage regulator
and
solid-state switch
L1
L2
12 VDC
C1
92
46
C2
98
to camera
station
signal unit
94
current
monitor
84
97
86
voltage
regulator
voltage
threshold
detector
90
88
voltage
cotrolled
oscillator

Fig. 3.

Fig. 4A.


BEGIN
402
INITIALIZE VARIABLES, DISPLAY ALARM; ACTIVATE POWER OUTPUT AT LOW LEVEL
440
POLL DISPLAY SETUP SWITCHES; AND DISPLAY SWITCHES SETUP ROUTINE
D
404
CONTINUOUS STATION SIGNAL UNIT AT 12 VDC?
NO
YES
406
DISPLAY: 'ALERT-CHECK SIGNAL UNIT'
408
FIRST TIME THROUGH LOOP:
NO
YES
410
EXECUTE ALARM SUBROUTINE
412
CONTINUOUS STATION SIGNAL UNIT AT 24 VDC?
NO
YES
416
DISPLAY: 'SIGNAL UNIT NOT READY FOR CABLE POWER'
414
DISPLAY: 'SIGNAL UNIT READY FOR CABLE POWER'
418
OUTPUT CURRENT LEVEL LESS THAN MAX?
YES
420
DISPLAY: 'CHECK LOAD ON CABLE'
422
FIRST TIME THROUGH LOOP?
NO
424
EXECUTE ALARM SUBROUTINE
426
POWER STATUS SIGNAL PRESENT?
NO
YES
430
DISPLAY: 'CAMERA UNIT NOT PRESENT'
428
DISPLAY: 'CAMERA UNIT PRESENT'
A
A
432
SIGNAL UNIT STILL AT 24 VDC?
NO
YES
434
DISPLAY: 'SYSTEM STANDBY:
436
POWER STATUS SIGNAL PRESENT?
NO
YES
438
DISPLAY: 'SYSTEM POWER READY'
442
DISPLAY: 'AUTO POWER NOW'
444
EXECUTE ALARM POWER-ON ROUTINE: CLEAR INTERRUPT MASK; ENABLE CURRENT SURGE MONITORING; CLOSE POWER SWITCH
446
INCREMENT OUTPUT VOLTAGE; EXECUTE 'WAIT' SUBROUTINE.
448
OUTPUT VOLTAGE AT 48 VDC?
NO
YES
450
EXECUTE WAIT ROUTINE.
C
DETERMIN REMOTE VOLTAGE FROM POWER STATUS SIGNAL.
452
B

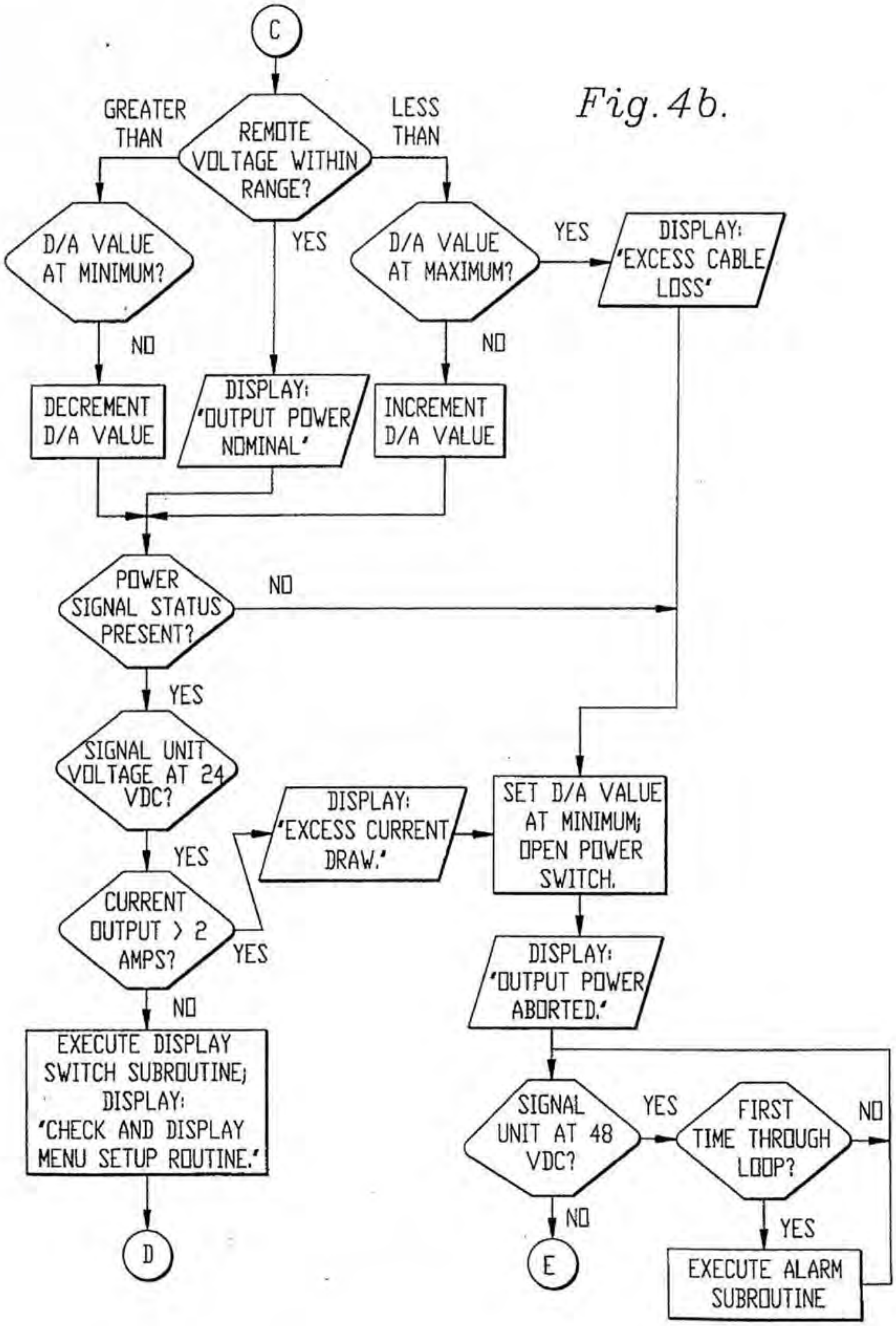

C
REMOTE VOLTAGE WITHIN RANGE?
GREATER THAN
LESS THAN
YES
D/A VALUE AT MINIMUM?
D/A VALUE AT MAXIMUM?
YES
DISPLAY: 'EXCESS CABLE LOSS'
NO
NO
DECREMENT D/A VALUE
DISPLAY: 'OUTPUT POWER NOMINAL'
INCREMENT D/A VALUE
POWER SIGNAL STATUS PRESENT?
NO
YES
SIGNAL UNIT VOLTAGE AT 24 VDC?
YES
DISPLAY: 'EXCESS CURRENT DRAW.'
SET D/A VALUE AT MINIMUM; OPEN POWER SWITCH.
CURRENT OUTPUT > 2 AMPS?
YES
NO
DISPLAY: 'OUTPUT POWER ABORTED.'
EXECUTE DISPLAY SWITCH SUBROUTINE; DISPLAY: 'CHECK AND DISPLAY MENU SETUP ROUTINE.'
SIGNAL UNIT AT 48 VDC?
YES
FIRST TIME THROUGH LOOP?
NO
NO
YES
D
E
EXECUTE ALARM SUBROUTINE

Fig. 4b.

SIGNAL TRANSFER AND POWER DELIVERY SYSTEM FOR A TELEVISION CAMERA STATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of television production using remotely located cameras. More particularly, the invention concerns a system for providing both signaling and power over a single coaxial cable between a television control station and a remote camera station and for controlling the voltage delivered to the camera station.

2. Description of the Prior Art

On-location production of television programs typically involves the use of a production control center housed in a trailer or van connected with a number of remote camera stations by way of control and power cables. Each camera station typically includes a camera, camera operator headset, talent earpiece, and talent microphone. The control cables must have the capability of carrying a wide variety of signals including camera video and program audio signals from the camera station to the control facility, and two-way intercom audio between the control facility and the camera operator and talent. The cables also carry various control signals from the control center to the camera station such as system master reference signals including color black and a composite video signal (black burst) used as a synchronizing signal (gen-lock), and an on-air tally signal which activates the tally light on the camera viewable by the talent as an on-air cue.

In one prior art cabling technique, a plurality of coaxial cables are used for carrying signals and power is provided to the camera station by a portable power generator or conventional drop cords connected to the nearest A.C. outlet. The number of individual cables required for this technique can range from two to a more common seven consisting of four audio twisted pairs and three coaxial cables plus a power cord. As those skilled in the art will appreciate, a seven-line bundle for one camera station weights about ninety pounds for a reach of three hundred fifty feet.

Another cabling technique uses a multi-conductor cable containing several narrow diameter mini-coaxial cables and several wire pairs for audio and power. A more recent development uses a triaxial cable in which video and audio signals are modulated and multiplexed along the center conductor and the intermediate conductor with power provided over the center and outer conductors.

As those skilled in the art appreciate, all of these prior art cabling techniques are expensive and the cabling is relatively heavy and stiff making it awkward to carry and route. An even more recent technique is called the CAMPLEX system and uses a single coaxial cable over which all of the signalling is modulated and multiplexed. Because only a single coaxial cable is used, the use of this system is inexpensive and the single cable is very easy to carry, route and splice. This system does require, however, a separate power supply such as a conventional drop cord or the use of camera's internal battery.

SUMMARY OF THE INVENTION

The signal transfer and delivery system of the present invention solves the prior art problems discussed above and provides a distinct advance in the state of the art. More particularly, the invention hereof provides both signalling and power over a single conductor pair.

Broadly speaking, the present invention includes respective control and remote station modules operable for transferring signals between a conductor pair. The control station module includes a power delivery unit for delivering power to the conductors; the remote station module includes a power reception unit for receiving power from the conductors and delivering the power to the remote stations. The remote station module also includes means for sensing the status of the power at the remote station, for producing the power status signal representative of the power status and for transferring the status signal to the conductors. The power delivery unit includes means for receiving the status signal and for controlling the delivery of power accordingly to the conductors.

More particularly, the power status signal is representative of the D.C. voltage delivered to the power station. The power delivery unit controls the D.C. voltage delivered to the conductors in order to maintain the desired remote voltage despite variations in power consumption by the camera station and losses in the cable.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of a television production facility in accordance with the present invention;

FIG. **2** is an electrical block diagram illustrating the power delivery unit of FIG. **1**;

FIG. **3** is an electrical block diagram illustrating the power reception unit of FIG. **1**;

FIG. **4A** is a computer program flow chart illustrating the operation of the microcontroller of FIG. **2**; and

FIG. **4B** is a continuation of the computer program flow chart of FIG. **4A**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** is a schematic representation of signal transfer and power delivery apparatus **10** illustrated as part of television production facility **12** which includes control station **14** and camera station **16**. Control station **14** includes conventional television production equipment well known to those skilled in the art such as the production switcher, video and audio transmitters, camera monitors, preview monitors, program monitors, director's intercom, control signal generators, and control signal receivers. Camera station **16** is also conventional in nature and includes D.C. powerable video camera **18**, talent earpiece **20**, camera operator intercom headset **22**, and talent microphone **24**.

Apparatus **10** broadly includes control station module **26** and camera station module **28** interconnected by conventional 75-Ohm coaxial cable **30**. Control station module **26** is also coupled with control station **14** for bi-directional signal transfer therewith, and camera station module **28** is coupled with components **18–24** of camera station module **16** also for bi-directional signal transfer therewith.

Control station module **26** includes control station signal unit **32** and power delivery unit **34**. Signal unit **32** is preferably a conventional signal multiplexing unit such as a CAMPLEX console adaptor available from Concept W Systems, Inc. of Emporia, Kans. Signal unit **32** is operable to receive a plurality of signals from control station **14** and to combine and multiplex those

signals onto coaxial cable portion **36** for transmission to camera station **16** by way of power delivery unit **34** and camera station module **28**. Similarly, unit **32** is operable to receive multiplexed signals over cable portion **36** and to separate the signals for presentation to control station **14**. In operation, preferred signal unit **32** imposes 12 VDC on line **36** when energized and imposes 24 VDC when activated for signal transfer. In the context of the present invention, these two voltages are used as signals indicative of the presence and signal operation of unit **32** as explained further herein.

FIG. **2** illustrates power delivery unit **34** which, in general, delivers power in the form of D.C. voltage and current to cable **30** for transmission thereover to camera station module **28** which then separates the power from the signals for delivery to the appropriate components of camera station **16**. Power delivery unit **34** includes variable output D.C. power supply **38**, transformer **40**, current monitor **42**, solid state switch and current surge detector/limiter **44**, voltage divider **46**, signal separator and power combiner **48**, RF choke **50**, tracking filter and square wave generator **52**, microcontroller **54**, digital-to-analog converter (DAC) **56**, alpha-numeric display **58**, display setup switches **60** and **62**, and audible alarm **64**.

Power supply **38** (Vicor FlatPAC VI-LE4-CW) receives 120 VAC power from a conventional source thereof and delivers an output D.C. voltage to common mode transformer **40** (RENCO RL-1329-5-1000) used to remove high frequency noise from the output voltage. The output voltage from power supply **38** varies between about 15 and 48 volts in accordance with the analog signal received from DAC **56**.

The input and output terminals of one leg of transformer **40** are coupled to the respective inputs of current monitor **42** which includes two reference diodes **66** and **68** (LM336) and operational amplifier **70** (NE5532). Diodes **66**,**68** provide calibrated voltage offsets to the inputs of amplifier **70**. Monitor **42** detects the current flow from power supply **38** by monitoring the voltage drop across the monitored leg of transformer **40** and thereby provides an output voltage to microcontroller **54** between 0 and 5 VDC corresponding to a power supply output current flow between 0 and 2 amps.

Detector/limiter **44** receives the power flow from transformer **40** and provides two levels of current limiting. One level limits current to a low level at 15 milliamperes using two transistors conventionally configured as a constant current amplifier between the input and output. As explained further hereinbelow, this low level of output power is applied to cable **30** when power delivery unit **34** is initially energized. The second level of current limiting is for high level or operating power and conventionally includes a power field effect transistor (FET) (MTP8P10) used as a power switch and a second transistor (MPSA93) which monitors the voltage drop across a resistor in series with the FET power switch as a current limiter. Detector/limiter **44** receives a control input from microcontroller **54** which controls the on-off status of the power switch but which can be over-ridden by the second transistor. In this way, detector/limiter **44** presents a self-contained current limiter which prevents large current surges in the high power output as might be caused by a short in cable **30** as a result of being cut or pinched.

The output from detector/limiter **44** is coupled with voltage divider **46** and combiner **48**. Voltage divider **46** is composed of series-coupled resistors **72** and **74** with the connection therebetween coupled with microcontroller **54** as an input thereto. The values of resistors **72**,**74** are selected so that one tenth of the output voltage from detector/limiter **44** is provided to microcontroller **54** as a representative signal thereof.

Signal separator and power combiner **48** includes inductors **L1** and **L2** and capacitors **C1** and **C2** interconnected as shown. Series connected inductor **L1** and capacitor **C2** form a low pass filter with an insertion-/isolation loss of about 10 dB at about 290 Khz which is the frequency of the power status signal received by combiner **48** over cable **30** from camera station module **28** as explained further hereinbelow. Capacitor **C1** interconnects cable portion **36** and cable **30** for passing the various signals therebetween unaffected by the delivery of power to cable **30** by power delivery unit **34**. Capacitor **C1** forms a high pass filter with a 3 dB point at about 1.0 Mhz to isolate control station signal unit **32** from the power supplied to cable **30** by power delivery unit **34**.

As mentioned above, signal unit **32** also provides two D.C. voltage outputs at 12 and 24 volts respectively corresponding to power-up and signal activation. Choke **50** interconnects cable portion **36** at combiner **48** and microcontroller **54** which allows the passage of these two voltages for monitoring by microcontroller **54** while preventing passage of the RF signals passing between control station and camera station **16**. As explained further hereinbelow, microcontroller **54** monitors these two voltages provided by unit **32** in order to test for the presence and activation thereof.

Tracking filter and square wave generator **52** is a combination of a conventional phase locked loop (PLL) (EXAR XR-2211), voltage comparator and binary ripple counter. Generator **52** receives the power status signal as an input from combiner **48**. In turn, generator **52** provides two outputs, the first is in the form of a "signal valid" output which indicates the presence of the status signal to microcontroller **54**.

The second output is in the form of a reduced frequency square wave representative of the frequency of the input signal. This frequency represents the voltage provided to camera station **16** by camera station module **28** and is used by microcontroller **54** to control the output voltage delivered to cable **30** by power delivery unit **34**. The conventional PLL is configured to operate as a tracking filter tuned to lock to the status signal which typically presents a frequency range from 250 to 300 Khz. The output from the tracking filter's oscillator is provided as the input to a voltage comparator (LM393) which converts the input to an output square wave.

Passage through the tracking filter and comparator also provides selected amplification, removes spurious signals, and provides a logic level square wave signal to the binary ripple counter (CD4024). This ripple counter serves as a frequency divider (divide by 64) providing a lower frequency square wave as an input to microcontroller **54** which still retains the frequency variations of the input signal. The tracking filter also provides the "signal valid" output which is the "lock detect" output therefrom.

Microcontroller **54** (Motorola MC68705R3), in addition to the connections mentioned above, is also connected to audible piezo alarm **64**, to switches **60**,**62**, and to display **58** (available from Industrial Electronic Engineers, Inc. LCM-2006) as illustrated in FIG. **2**. The operation of components **58**–**64** is explained further

hereinbelow in connection with the flowcharts of FIGS. 4A,B.

Cable 30 interconnects control station module 26 with camera station module 28 for bi-directional signal transfer therebetween and for delivery of power from power delivery unit 34. Camera station module 28 separates the power from the signals on cable 30 and delivers the power to camera station 16 for operational use. Camera station module 28 includes power reception unit 76 and camera station signal unit 78. The preferred camera station signal unit is the CAMPLEX camera adaptor available from Concept W Systems, Inc. of Emporia, Kans. with the circuitry of power reception unit 76 integrated therewith to form a single integrated unit.

FIG. 3 is an electrical block diagram illustrating power reception unit 76 which includes signal combiner and power separator 80, current limited voltage regulator 82, current monitor 84, voltage regulator 86, voltage controlled oscillator 88 and voltage threshold detector 90.

Separator 80 includes inductors L1 and L2 and capacitors C1 and C2 interconnected as shown. Capacitor C1 presents a high pass filter with a 3 dB point at about 1 Mhz and thereby prevents passage of the D.C. power voltage to camera station signal unit 78 but allows bi-directional passage of the high frequency signals between cable 30 and signal unit 78. In contrast, series coupled inductors L1,L2 prevent passage of the high frequency signals but allow passage of the D.C. power as an output to regulators 82 and 84 as shown in FIG. 3.

Conventional regulator 82 receives the power input from separator 80 and provides a current limited output at about 12 VDC to camera station 16 and in particular to camera 18. Regulator 82 uses a power field effect transistor controlled by current monitor 84 to limit current throughput. More particularly, regulator 82 includes a zener-diode referenced operational amplifier (NE5534) which functions as a power output voltage error amplifier controlling a power field effect transistor (MTP8P10) which functions as a series regulator.

Regulator 82 is controlled by two signals. The first signal is a power control signal received from voltage threshold detector 90 which enables operation of the error amplifier and causes regulated power to pass through the transistor. The second signal is a current control signal that controls a second transistor to override the error amplifier output and thus controls the current through the power transistor.

Current monitor 84 generates a control signal used to activate the current limiting function of regulator 82. Monitor 84 includes zener diodes 92 and 94 (LM336) the anodes of which are connected to the input terminals of operational amplifier 96 (NE5230). The anode of output zener diode 98 (5.6 volts) is connected to the output of amplifier 96 and the cathode of diode 98 is connected to regulator 82 as a current control input thereto. The cathodes of diodes 92,96 are connected across inductor L2 of separator 80 to detect the current-induced voltage drop thereacross. The gain and offset of amplifier 96 is calibrated such that a voltage drop across inductor L2 equivalent to 2.0 amperes causes output diode 96 to conduct and thereby enable the current limiting function of regulator 82. Power control diode 97 interconnects the output of regulator 82 with current monitor 84 at the power control terminal thereof and with the output of threshold detector 90. Diode 97 holds monitor 84 and voltage regulator 82 in a power-on state after the power input voltage is adjusted down to its normal level of 15 VDC.

Voltage threshold detector 90 comprises a zener diode having the cathode coupled with the input to regulator 82 and having the anode thereof coupled to the power control terminal of regulator 82. Detector 90 prevents regulator 82 from supplying an output voltage until the input voltage rises above a threshold level of 24 VDC.

Voltage regulator 86 includes two transistors configured as a constant current amplifier between the power input and a zener diode coupled to ground at the power output. Regulator 86 provides a clean and stable operating power supply to oscillator 88 at the power-in terminal thereof.

Voltage controlled oscillator 88 (EXAR XR-2206) generates the power status signal as a frequency modulated signal between 250 and 350 Khz in accordance with the voltage applied to the control-voltage-in terminal corresponding to a range of 15 to 50 VDC. The voltage applied to this terminal is the D.C. voltage provided by separator 80 which in turn is the power voltage as received from power delivery unit 34. In this way, the frequency of the power status signal represents the voltage as delivered by cable 30 to camera station module 28. As those skilled in the art will appreciate, the delivered voltage can vary according to the power draw of camera station 16 and the length of cable 30. The power status signal represents the actual delivered voltage which is used by power delivery unit 34 to compensate.

The power status signal produced by oscillator 88 is coupled to cable 30 by way of inductors L1 and capacitor C2 which form a low pass filter with an insertion-/isolation loss of about 10 dB at the frequency of the status signal. With this configuration of power reception unit 76, the status of the delivered power, that is, the D.C. voltage thereof is sensed and a representative power status signal in the form of a frequency modulated signal is transferred to cable 30.

FIGS. 4A,B are computer program flowcharts illustrating the program for operating microprocessor 54. On power-up, the program enters at step 402 which initializes the software variables, inputs and outputs, display 58 and alarm 64. This step also activates power delivery unit 34 to deliver a low level voltage to cable 30 at 15 VDC limited to 15ma. To accomplish this, microcontroller 54 presents the appropriate binary code to DAC 56 which, in turn, produces an analog output to power supply 38 for producing the output at 15 VDC. This low level is delivered to cable 30 by way of transformer 40, detector/limiter 44 and combiner 48. Detector/limiter 44 limits the output current to 15ma. By limiting the output current to 15 ma, a short circuit in cable 30 causes the voltage thereon to drop from the nominal 15 VDC which is detected by voltage divider 46. When the voltage drops below 10 VDC, as represented by the signal delivered to microcontroller 54, a short circuit is indicated as discussed further hereinbelow.

Step 404 then asks whether control station signal unit 32 is producing an output at 12 VDC as received by microcontroller 54 by way of cable portion 36 and choke 50. As explained above, when control station signal unit 32 is initially energized, that is, powered up, it produces an output at 12 VDC. This output is used by the program to determine whether signal unit 32 is present and powered.

If the answer in step **404** is no, step **406** activates display **58** to display the message "alert-check signal unit." Step **408** then asks whether this is the first time through this portion of the program, and if yes step **410** initiates execution of a conventional alarm subroutine for activating audible alarm **64**. The display and audible alarm serve as a prompt to check the status of signal unit **32**. If the answer in step **408** is no, this indicates that the alarm subroutine was previously initiated and step **410** can be skipped. The program continues to loop through steps **404–410** until the presence of signal unit **32** is indicated by a yes answer in step **404**.

Step **412** then asks whether signal unit **32** is producing an output voltage at 24 VDC indicating activation thereof for signal transfer. If yes, step **414** initiates display of the message "signal unit ready for cable power." If the answer in step **412** is no, step **416** activates display **58** for the message "signal unit not ready for cable power."

After low level power output is initiated, step **418** then asks whether the current output is less than the maximum allowable as indicated by the voltage signal received by microcontroller **54** from voltage divider **46**. By limiting the output current to 15 ma., a short circuit in cable **30** causes a voltage drop which can be detected safely before full operating power is imposed. As those skilled in the art will appreciate, a short circuit may result if cable **30** is pinched or cut, but may also occur if the equipment at the remote end of cable **30** is defective or improperly connected.

If the answer in step **418** is no, indicating that a short circuit does exist, step **420** initiates display of the message "check load on cable." Step **422** then asks whether this is the first time through this loop of the program. If yes, step **424** initiates the alarm subroutine. If the answer in step **422** is no, or after step **424**, the program loops back to step **418** and continues through steps **418–424** until the problem is corrected.

If the test in step **418** is passed, step **426** then asks whether the power status signal is present as detected by tracking filter and square wave generator **52**. The presence of the status signal is provided to microcontroller **54** from the "signal valid" terminal of generator **52**. When low level power is imposed on cable **30** and power reception unit **76** is present and operational, oscillator **88** (FIG. **3**) senses the low level voltage delivered to reception unit **76**, produces the power status signal representative of the low level voltage and returns the signal by way of cable **30** back to delivery unit **34**. In this way both the presence and functionality of power delivery unit **76** are checked before full power is imposed on cable **30**.

If the power status signal is present, step **428** initiates display of the message "camera unit present." If the answer in step **426** is no, step **430** initiates display of the message "camera unit not present."

After steps **428** and **430**, step **432** asks whether the voltage signal from camera station signal unit **32** is still at the high level voltage of 24 VDC. If no, the message "system standby" is displayed indicating that power delivery unit **34** is ready to deliver power. If the answer in step **432** is yes, step **436** again asks whether the power status signal is present. If no, step **438** displays the message "system power ready." After steps **434** or **438**, step **440** polls setup switches **60,62** and in response, executes the "display menu setup" routine. More particularly, successive activation of "select" switch **60** causes display **58** to successively display the five bar-graph menu options of voltage bar graph on, off, current bar graph on, off or the combination voltage and current bar graph. When the desired menu option is displayed, activation of "enter" switch **62** selects the display bar graph option for display. The program then loops back to step **404**.

If the answer in step **436** is yes, then it is known that both control station signal unit **32** and power reception unit **76** are ready for full power operation. Step **442** then displays the message "auto power now." Step **444** then executes the alarm power-on routine and clears the interrupt mask. Step **444** also enables the current surge monitoring by detector/limiter **44** by providing an input to the power control terminal thereof from microcontroller **54**. This action also closes the power transistor and detector/limiter **44** which delivers full power output to cable **30**.

Initially full power output is imposed at the lower end of the allowable range (between about 15 and 50 VDC) and step **446** then increments the output voltage by incrementing the binary code delivered to DAC **56**. The program then executes a standard wait subroutine then asks in step **448** whether the output voltage as delivered to cable **30** is at 48 VDC. If no, the program continues to loop through steps **446** and **448**, incrementing the voltage each time until 48 VDC is achieved taking about one fourth second to bring the voltage up to this level. When this occurs, step **450** again executes the wait routine to allow the voltage to stabilize at power reception unit **76**.

During this time, the solid state switch of regulator **82** (FIG. **3**) is open and no power output is provided until the voltage reaches 24 VDC. At this point voltage threshold detector **90** activates regulator **82** which begins producing an output at 12 VDC. In turn, this output latches in current monitor **84** and regulator **82** by way of diode **97**. In step **452**, microcontroller **54** then reads the power status signal as presented by generator **52** from the square wave output terminal thereof. In other words, in this step the program determines the voltage as present at power reception unit **76**.

The program next moves to step **454** in FIG. 4B which asks whether the voltage as received by power reception unit **76** is within the allowable range. A range is provided as a so-called "dead band" to keep the program from "hunting." If the answer in step **454** is yes, the program moves to step **456** which displays the message "output power nominal."

If the received voltage is greater than the allowable range, step **458** asks whether the binary value to DAC **56** is already at its allowable minimum. If no, step **460** decrements the binary value.

If step **454** indicates that the received voltage is less than the range, step **462** asks whether the binary value presented to DAC **56** is already at its maximum. If no, step **464** increments this binary value to increase the voltage.

If the answer in step **458** is yes, or after steps **460, 456** or **464**, step **456** asks whether the power status signal is still present as indicated by the "single valid" output on generator **52** (FIG. **2**). If yes, step **468** then asks whether control station signal unit **32** is still activated as indicated by its voltage output signal at 24 VDC.

If the answer in step **468** is yes, step **470** then reads the current output as represented by the signal from current monitor **42** and asks whether this value is greater than the allowable two amps. If the current flow is below this allowable limit, the answer in step **470** is no and step

472 then polls switches 60,62 and executes the display menu setup routine as discussed in connection with step 440. The program then loops back to step 452 (FIG. 4A) for continued monitoring of received voltage and allowable current limits.

If the answer in step 462 is yes, indicating that the binary value delivered to DAC 56 is already at its maximum value, then step 474 displays the message "excess cable loss." In other words, if power delivery unit 34 is delivering its maximum output voltage but the voltage as received by power reception unit 76 is still less than the desired range, then a problem is indicated most likely caused by excess cable length in combination with excessive current draw by camera 18.

If such is the case, then operation should not continue and step 476 resets the binary value presented to DAC 56 and shuts off the output power by deactivating the signal from microcontroller 54 to the power control terminal of detector/limiter 44. A problem is also indicated and step 476 is executed if the power status signal disappears as indicated by no answer in step 456, or if the high level voltage signal from control station signal unit 32 disappears as indicated by a no answer in step 468.

Similarly, if the answer in step 470 is yes indicating an excess current draw, step 478 displays the message "excess current draw" and the program again moves to step 476 to shut off power output. After step 476, the program moves to step 480 which displays the message "output power aborted."

Step 482 next asks whether control station signal unit 32 is still providing its output voltage signal indicating activation. If yes, step 484 asks whether this is the first time through this loop of the program. If the answer to this step is yes, step 486 then executes the alarm subroutine to activate audible alarm 64. If the answer in step 484 is no, or after step 486, the program loops back to step 482.

If the answer in step 482 is no, indicating that control station signal unit 32 is not active, the program loops back to step 404 (FIG. 4A) to reinitiate the start-up process.

Those skilled in the art will appreciate that the present invention encompasses many variations in the preferred embodiment described herein. For example, a two wire pair may be used instead of the preferred coaxial cable in some circumstances. The preferred power status signal could also represent actual power flow or current flow. As a final example, the present invention also presents utility for signalling and power delivery in applications other than the preferred television production environment.

Having thus described the preferred embodiment of the present invention, the following is claimed as new and desired to be secured by Letters Patent:

1. An apparatus for transferring video, audio or control signals between a control station and a remote station and for providing operating power to the remote station over a pair of conductors, said apparatus comprising:

control station signal means including means for coupling with the control station and with the conductors for transferring signals therebetween;

remote station means including means for coupling with the remote station and with the conductors for transferring signals therebetween; and

power delivery means, including means for coupling with the conductors, for delivering power from a source thereof to the conductors,

said remote station means including power reception means for receiving said power from the conductors and for delivering said power to the remote station, and for sensing the status of said power at said remote station means, for producing a power status signal representative of said status, and for transferring said status signal to the conductors,

said power delivery means including means for receiving said status signal and for controlling the delivery of said power in accordance therewith;

said power status signal being representative of a D.C. voltage received at said remote station means as delivered by said power delivery means.

2. The apparatus as set forth in claim 1, said conductors being configured as a coaxial cable.

3. The apparatus as set forth in claim 1, said power delivery means including means for delivering power in the form of D.C. voltage and current.

4. The apparatus as set forth in claim 1, said power delivery means including means for varying the D.C. voltage delivered to the conductors in accordance with said status signal in order to maintain the D.C. voltage as received at said remote station.

5. The apparatus as set forth in claim 3, said power reception means including means for producing said status signal as an A.C. signal which varies in frequency in accordance with said received D.C. voltage.

6. The apparatus as set forth in claim 5, said status signal producing means including a voltage controlled oscillator.

7. The apparatus as set forth in claim 1, the remote station including a television camera, said power receiving means including means for delivering operating power to the camera.

8. The apparatus as set forth in claim 1, said power delivery means including means for monitoring current flow delivered to said conductors and for limiting said current flow to a predetermined level.

9. An apparatus for transferring video, audio or control signals between a control station and a remote station and for providing operating power to the remote station over a pair of conductors, said apparatus comprising:

control station signal means including means for coupling with the control station and with the conductors for transferring signals therebetween;

remote station means including means for coupling with the remote station and with the conductors for transferring signals therebetween; and

power delivery means, including means for coupling with the conductors, for delivering power from a source thereof to the conductors,

said remote station means including power reception means

for receiving said power from the conductors and for delivering said power to the remote station, and

for sensing the status of said power at said remote station means, for producing a power status signal representative of said status, and for transferring said status signal to the conductors,

said power delivery means including means for receiving said status signal and for controlling the delivery of said power in accordance therewith,

said power delivery means including means for delivering power at a first level and at a second reduced level, for initially delivering said power at a reduced level, and for testing for excessive current flow in the conductors at said reduced level before delivering power at said first level.

10. The apparatus as set forth in claim **9**, said power delivery means including means for detecting said status signal during delivery power at said reduced level and for preventing delivery of power at said first level in the absence of said status signal.

11. The apparatus as set forth in claim **9**, said control station signal means including means for producing a station signal for delivering said station signal to said delivery means, said power delivery means including means for receiving said station signal and for preventing production at said first power level in the absence of said station signal.

12. The apparatus as set forth in claim **9**, said power delivery means including means for delivering said power in the form of D.C. voltage and current, said first and second levels being respective levels of D.C. voltage.

13. The apparatus as set forth in claim **12**, said power reception means including means for preventing delivery of output power therefrom until the voltage received thereat exceeds said second reduced level.

14. The apparatus as set forth in claim **9** said conductors being configured as a coaxial cable.

15. The apparatus as set forth in claim **9**, said power delivery means including means for delivering power in the form of D.C. voltage and current.

16. The apparatus as set forth in claim **9**, the remote station including a television camera, said power receiving means including means for delivering operating power to the camera.

17. The apparatus as set forth in claim **9**, said power delivery means including means for monitoring current flow delivered to said conductors and for limiting said current flow to a predetermined level.

18. An apparatus for transferring video, audio or control signals between a control station and a television camera station and for providing operating power to the camera station by way of a coaxial cable, said apparatus comprising:

a control station module including means for coupling with the control station and with the cable including

control station signal means for transferring signals between the control station and the cable,

power delivery means for delivering power in the form of D.C. voltage and current from a source thereof to the cable; and

a camera station module including means for coupling with the cable and with the camera station including

camera station signal means for transferring signals between the camera station and the cable; and

power reception means for receiving said power from the cable and for delivering said power to the camera station.

said power reception means including voltage sensing and signal means for sensing the voltage of said power delivered to said camera station, for producing a power status signal representative of said voltage, and for transferring said status signal to said cable,

said power delivery means including voltage control means for receiving said status signal and for controlling said delivery of power in accordance therewith for maintaining said voltage delivered to said camera station at a predetermined level despite variations in power consumption by said camera station and losses in the cable,

said power reception means including means for producing said status signal as an A.C. signal which varies in frequency in accordance with said received D.C. voltage.

19. The apparatus as set forth in claim **18**, said status signal producing means including a voltage controlled oscillator.

20. The apparatus as set forth in claim **18**, said power delivery means including means for monitoring current flow delivered to the cable and for limiting said current flow to a predetermined level.

21. The apparatus as set forth in claim **18**, said power delivery means including means for delivering power at a first and at a second reduced level, for initially delivering said power at said reduced level, and for detecting said status signal during delivery power at said reduced level and for preventing delivery of power at said first level in the absence of said status signal.

22. An apparatus for transferring video, audio or control signals between a control station and a television camera station and for providing operating power to the camera station by way of a coaxial cable, said apparatus comprising:

a control station module including means for coupling with the control station and with the cable including

control station signal means for transferring signals between the control station and the cable,

power delivery means for delivering power in the form of D.C. voltage and current from a source thereof to the cable; and

a camera station module including means for coupling with the cable and with the camera station including

camera station signal means for transferring signals between the camera station and the cable; and

power reception means for receiving said power from the cable and for delivering said power to the camera station,

said power reception means including voltage sensing and signal means for sensing the voltage of said power delivered to said camera station, for producing a power status signal representative of said voltage, and for transferring said status signal to said cable,

said power delivery means including voltage control means for receiving said status signal and for controlling said delivery of power in accordance therewith for maintaining said voltage delivered to said camera station at a predetermined level despite variations in power consumption by said camera station and losses in the cable,

said power delivery means including means for delivering power at a first level and at a second reduced level, for initially delivering said power at a reduced level, and for testing for excessive current flow in the cable at said reduced level before delivering power at said first level.

23. The apparatus as set forth in claim **22**, said power delivery means including means for detecting said status signal during delivery power at said reduced level and

for preventing delivery of power at said first level in the absence of said status signal.

24. The apparatus as set forth in claim **22**, said control station signal means including means for producing a station signal for delivering said station signal to said delivery means, said power delivery means including means for receiving said station signal and for preventing production at said first power level in the absence of said station signal.

25. The apparatus as set forth in claim **22**, said power delivery means including means for delivering said power in the form of D.C. voltage and current, said first and second levels being respective levels of D.C. voltage.

26. The apparatus as set forth in claim **25**, said power reception means including means for preventing delivery of output power therefrom until the voltage received thereat exceeds said second reduced level.

27. The apparatus as set forth in claim **22**, said power delivery means including means for monitoring current flow delivered to the cable and for limiting said current flow to a predetermined level.

28. The apparatus as set forth in claim **22**, said power delivery means including means for delivering power at a first and at a second reduced level, for initially delivering said power at said reduced level, and for detecting said status signal during delivery power at said reduced level and for preventing delivery of power at said first level in the absence of said status signal.

29. A method of transferring audio or control signals between a control station and a television camera station and for providing operating power to the camera station by way of a coaxial cable, said method comprising steps of:

transferring signals between the control station and the cable:

using a power delivery unit for delivering power as delivered power in the form of D.C. voltage and current from a source thereof to the cable;

transferring signals between the camera station and the cable;

receiving said power as received power from the cable and delivering said power to the camera station,

sensing the voltage of said received power as received voltage;

producing a power status signal representative of said received voltage;

transferring said status signal to the cable; and

receiving said status signal from the cable into said power delivery unit and controlling said delivered voltage in accordance with said status signal for maintaining said received voltage at a predetermined level in order to compensate for voltage drop in said cable,

further including the steps of initially delivering power at said delivery unit at said reduced voltage,

testing for excess current flow into said cable from said power delivery unit at said reduced voltage, and

preventing delivery of power at an operational level of voltage higher than said reduced voltage upon the occurrence of said excess current flow.

30. The method as set forth in claim **29** further including the steps of

initially delivering power from said delivery unit at a reduced voltage,

testing for reception of said status signal at said reduced voltage, and

preventing delivery of power at an operational level of voltage higher than said reduced voltage in the absence of said status signal during delivery at said reduced voltage.

31. The method as set forth in claim **29** further including the steps of

testing for reception of said status signal at said reduce voltage, and

preventing delivery of power at said operational level in the absence of said status signal.

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